XIII. *Obſervations on Sand Iron: In a Letter from Mr.* Henry Horne, *to Mr.* John Ellicot, *F. R. S.*

SIR,

Read March 3, 1763.

AS the affair of the rich American Iron Ore, commonly known by the name of the Virginia black ſand, has of late not only engaged the converſation of many of the Virtuoſi, but has been taken very particular notice of by the Society for the encouragement of arts and manufactures; I thought myſelf obliged, for many reaſons, to lay before you whatever has come to my knowledge relating to this diſcovery, either from my own experiments, or from the information of others. And I engage in this ſervice with the greater pleaſure, as I look upon it to be one of the moſt intereſting diſcoveries, with regard to this uſeful metal, that has come to our knowledge for ſome ages, and, if rightly conducted, may prove of infinite ſervice to us in this part of the world, as well as to the inhabitants of our colonies, where (as it has been ſuppoſed, though without ſufficient foundation) this diſcovery was firſt made.

Without any farther preface or apology, permit me to remind you, that, in a converſation which formerly paſſed between us upon this ſubject, I acquainted you, that, about twenty years ſince, I was engaged in making a variety of experiments upon the nature of Iron Ores, and Steel; and that I then made a very particular enquiry into the nature of this black ſand, and, in the courſe of theſe experiments, ſeveral very intereſting phenomena diſcovered themſelves, which, as they might be of great ſervice to the world in general, and more eſpecially to ſuch as are concerned in ſmelting of the iron from the ore, I had thoughts of communicating to the publick; but, as my buſineſs will not permit me to go through the whole at preſent, I ſhall confine myſelf to what relates to the black ſand.

I procured, from Mr. Adams the Virginia merchant, a ſufficient quantity of the ſand, and, in order to eſtimate its comparative weight with that of iron ore, I procured ſome of the richeſt ore I could get, which having reduced to powder, I filled an ordinary tea-cup with it. I afterwards filled the ſame cup with ſome of the ſand, and upon comparing the weights with each other, I found that the weight of the ſand was to that of the ore as 3 to 2; and having taken notice how readily the ſand was attracted by the magnet, I was convinced that the ſand muſt certainly contain a very conſiderable quantity of Iron, and therefore determined to make trial of it. I was however, for ſome time, interrupted in my deſign, by information I received from a friend, that ſuch an enquiry had been made many years before, by a member of the Royal Society, and a gentleman of eſteem as a chemiſt, but without ſucceſs; and that the experiments were publiſhed in the 2d vol. of Lowthorp's Abridgment of the Philoſophical Tranſactions. As this account is very ſhort as well as curious, I ſhall take the liberty to give it you entire, with ſome few remarks upon it.

" A black ſhining ſand from Virginia examined by Dr. All. Moulen.

A ſmall vial filled with ordinary white ſand, and containing only ʒ i. gr. xi. being filled with the Virginia ſand, was found to contain ʒij, ℈ij. gr. i.

This ſand did apply to the magnet both before and after calcination; but the latter did apply better to it than the former.

A parcel of this ſand, mixed and calcined with powdered charcoal, and kept in a melting furnace for about an hour, yielded no regulus: but applied more vigorouſly to the Loadſtone than either of the former.

I fluxed a parcel of this ſand with fixed nitre, in a melting furnace, for above an hour, but could obtain no regulus; nor any ſubſtance that would apply to the magnet, except a thin cruſt that ſtuck firmly to a piece of charcoal that dropt into the crucible when the matter was in fuſion.

I fluxed it alſo with ſalt-petre and powdered charcoal, dropping pieces of charcoal afterwards into the crucible. It continued about half an hour in the melting furnace in fuſion, and that without producing a regulus, or a ſubſtance that would apply to the magnet, excepting only what ſtuck to the charcoal as in the former experiment.

I fluxed another parcel of it with ſalt-petre and flower of brimſtone, without being able to procure any regulus.

I poured good ſpirit of ſalt on a parcel of this ſand, but could obſerve no luctation thereby produced.

I poured ſpirit of nitre, both ſtrong and weakened with water, on parcels of the ſame ſand, without being able to diſcover any conflict.

I poured ſingle aqua fortis upon another parcel of it, without being able to perceive any ebullition worth noting.

I uſed alſo double aqua fortis upon another parcel of it, which, for ought I could diſcover, had no more effect on it than the former.

I poured ſome aqua regia on a parcel of it, without diſcovering any ſenſible effect. I poured good oil of vitriol upon another parcel of this ſand; but ſeeing no bubbles thereby produced, I weakened the oil with water, but without any viſible effect.

I repeated all the former experiments with the menſtruums upon this ſand after calcination per ſe in a crucible, but could ſcarce obſerve a bubble produced by any of them.

I poured ſome of each of the liquors upon parcels of the powder of this ſand calcined, without any ſucceſs.

Note, that I made theſe experiments both in the cold, and upon a ſand furnace. So that to me there ſeems to be but little wanting to diſcover any metal known to us, if it contained any ſuch: for there is no metal nor ore that ſome of theſe menſtruums will not work on.

I powdered a fragment of a loadſtone, and poured ſome of theſe menſtruums upon it, without being able to find that they in the leaſt preyed upon it, any more than they did upon the ſand.

I poured ſome of the aforementioned menſtruums upon ordinary ſand taken out of a ſand furnace, where it muſt have ſuffered ſome calcination; but could find no more bubbles produced thereby, than what might rationally be ſuppoſed to be produced from lime, and other dirt mixed with the ſand."

Having thoroughly conſidered theſe experiments, they appeared to me far from being deciſive, and that if the Doctor had placed more confidence in the power of the magnet, and leſs in his menſtruums, he would rather have concluded that there might be ſome ſorts of iron ore which his menſtruums would not touch in the moiſt way, nor any regulus be produced from them in the dry, as he made uſe of them, which yet might, under ſome other hands, be ſubdued, by more apt and powerful methods than any which at that time he was acquainted with.

However I apprehended I might fairly draw this concluſion from his experiments, viz. that the ſand was not altogether and ſimply iron, but that it was ſtrongly united with a very ſtubborn, fixed, and permanent earth, which could not be ſeparated from it without ſome extraordinary, as well as powerful means; but I could not think this a ſufficient objection to the proſecution of an experiment, which, if it ſucceeded, might be attended with very happy conſequences. Proceeding therefore upon this ſuppoſition, I mixt up about 8 or 9 ounces of the ſand, with a proportional quantity of a ſtrong corroſive flux, which I put together into a crucible, and committed it to a very ſtrong fire in an excellent wind-furnace, where I kept it for between two and three hours, hoping by this means to have anſwered the intended purpoſe; but I confeſs I was not a little ſurpriſed, that, after the crucible was taken from the fire, I could not find one ſingle grain of metal in the remaining contents.

This diſappointment greatly puzzled me, till having thoroughly examined into the unexpected event, without being able to diſcover any reaſon ſufficient to incline me to recede from my former opinion, as to the component parts of the ſand, I concluded that the flux might poſſibly be a very improper one; for though it might have effected the intended ſeparation, yet it might at the ſame time be ſufficiently powerful to divide the particles of the metal, when ſeparated, ſo very minutely, as to be capable of ſubliming and carrying them off imperceptibly: And finding the contents greatly diminiſhed, ſo that the quantity remaining bore but a ſmall proportion to that which was firſt put into the crucible, I concluded that this muſt really have been the caſe, and that ſome very different method muſt be purſued in order to produce the deſired effects. I immediately determined to make a ſecond trial, in which I proceeded in the following manner. I took the ſame quantity of ſand made uſe of in the former experiment; and firſt I ſpread it, without any addition to it, upon an iron plate over a ſtrong fire, where I gave it a very powerful torrification (or roaſting) to try if, by that means, I could not relax, and looſen the component parts to ſuch a degree, as to make the ſeparation and reduction of the metal more eaſy, when I ſhould bring it into the furnace. When I had ſo done, I mixed it up with a flux of a very peculiar, but gentle nature, which I had before made uſe of for other purpoſes with great ſucceſs, and committed it (as in the former experiment) to the furnace, where I urged it by a very ſtrong fire for about

three

three hours, and upon taking it out, I found the event anſwerable to my moſt ſanguine expectations: for in the bottom of the crucible I found, as near as I can remember, rather more than half of the ſand I put into the crucible reduced to a very fine malleable metal.

In this very agreeable experiment I met with a very ſurprizing phænomenon, which, as I am not at preſent able to determine whether it was only caſual, or what would always happen in the like experiments, you will excuſe my divulging at preſent, eſpecially as you, Sir, by furniſhing me with a freſh parcel of the ſand, have enabled me to make ſome farther trials; which I ſhall embrace the firſt opportunity of doing; and ſhould I be ſo happy as to confirm what I then obſerved, or to make any farther diſcoveries deſerving your notice, I ſhall not fail communicating them to you.

Being fully convinced, by the experiment, that the ſand was a very rich iron ore, I acquainted ſome of my friends with it, who being largely engaged in trade to thoſe parts of our American colonies, where I was informed this ſand was to be eaſily procured, and in very large quantities, I was in great hopes an account of this nature would have inclined ſome of the gentlemen in that part of the world, to have proſecuted ſo uſeful a diſcovery in a larger way; and I own I have often wondered, that an affair of ſuch conſequence ſhould have lain dormant for ſo many years.

However I was a few months ſince pleaſingly ſurpriſed, to find in the hands of my very ingenious friend Mr. Peter Collinſon, not only a pamphlet, but likewiſe a letter upon the ſubject addreſſed to the Society for encouraging of arts and manufactures, by one Mr. G. Elliott, who relates, that, though previous to his attempt of making iron from this ſand, he met with nothing but what was diſcouraging from the moſt ſkillful perſons to whom he propoſed his deſign, yet that he had ſuch a perſuaſion in his own mind of the practicability of the thing, that he could not reſt till he had made a trial, and the event proved encouraging much beyond his expectations, inſomuch that he could ſcarcely believe the trial had been fairly made, till a ſecond trial evinced with certainty, that eighty three pounds of the ſand would produce a barr of excellent iron weighing fifty pounds: a prodigious yield indeed, and far beyond what I have ever heard of from the richeſt common ores that are any where to be found; moſt of the ores I have ever met with or heard of, yield little more than half in pig metal, and which will ſuffer a waſte of near $\frac{1}{6}$ part to make tolerable good barr iron, and much more if I am rightly informed, when the iron is intended for more valuable purpoſes, ſuch as being drawn into wire, &c.

After I had ſeen his addreſs in his letter to the Society, and his pamphlet; by the aſſiſtance of my friend Mr. Collinſon, I ſent him over two or three hints, which I judged might be of ſome ſervice to him; this produced the favour of a letter from him, of which the following is an exact copy.

Mr. HENRY HORN,

Sir, Killingworth, Oct. 4. 1762.

I Underſtand by Mr. Collinſon, that you have ſeen, and greatly approve of, the ſample of ſand iron which was ſent; that you are deſirous to know how it was made, and whether it can be made in large barrs. The little barr you ſaw, was cut off from a barr of 52 pounds and a half, the firſt that was made at my ſon's work, the firſt that was ever made in America, and probably the firſt that was ever made in the world, in that manner, and ſo large a barr. I never heard of any attempt made upon the iron ſand, till that of yours 20 years ago, of which Mr. Collinſon gave me an account in his letter.

As to the manner of making the iron, it is wrought or ſmelted in a common bloomary, in the ſame manner as other iron ore is ſmelted; excepting this difference, this iron ſand is ſo pure, ſo clean waſhed, that there is not a ſufficient quantity of cinder or ſlagg to promote and perform the ſmelting, therefore we add either the ſlagg which iſſues from other iron, or elſe add ſome bog mine ore, which abounds with cinder; in this way it is as capable of being wrought as rock ore or bog mine.

I was in hopes that if this iron ſand could be wrought at all, the particles being ſo very fine, it would ſmelt very quick; but herein I found myſelf miſtaken, every particle has a will of its own, and muſt have its own particular ſmelting, for inſtead of its being performed in leſs time, it took more than common iron ore, but, upon farther experience, and more acquaintance with this ſand, the workman has ſhortened the operation from five hours down to three: if by any means it might be reduced to the ſame time with pigg iron, it would be a moſt uſeful improvement. If you can afford any directions to haſten the operation; I ſhould be greatly obliged for any inſtructions.

There is ſo much of this ſand in America, that I am apt to think, that there is more iron ore in this form of ſand than in mines.

I have writen an eſſay upon the ſubject, which I hope Mr. Collinſon will let you ſee, as I hope to ſee what you are about to publiſh. My ſon has a ſteel furnace, which was erected ſeveral years before the act of parliament prohibiting them in the plantations: he has converted ſome of the ſand iron into ſteel, of which I ſend you a ſample; as alſo a ſample of the iron. As my ſon had no inſtructions for making ſteel, we were forced to hammer out the ſkill by various trials as we could; ſo conclude that he is ſtill imperfect, and wants your help and direction to bring it to perfection, in which art I underſtand that you are a perfect maſter, and withall kind enough to offer your aſſiſtance; for which I am very thankful, and look upon it as an aditional favour, if you will be pleaſed to indulge me with the benefit of your correſpondence, for I live in a corner of the world where ſuch information as, I truſt, you are able to furniſh, will be highly beneficial. Previous to my attempt of making iron from ſand, I propoſed my project to thoſe who were the moſt ſkillful in thoſe affairs, but met with nothing but what was diſcouraging; yet after all, had a perſuaſion of the practicability of the thing to a degree next to enthuſiaſm, ſo that I could not reſt till I had made trial. I am glad that the iron has ſuch qualities as to meet with your approbation; I knew that the iron was good, but did not know that it was ſo good as your ſuperior knowledge has found it. I want to know what ſuch iron will ſell for in England, whether it will be worth while to ſend it. This black ſand is a treaſure that has long lain hidden from the world, and is what may render the colonies more valuable to Great Britain.

I am, Sir,

Your moſt obliged humble ſervant,

Jared Eliot.

P. S. The barrs of iron which have hitherto been made of ſand, are from fifty to fifty groſs, hope in time to have them reach to ſeventy pounds weight each; experience muſt determine that matter, we can do better than at the time the eſſay was written. We have been viſited with a long and ſore drought, have done nothing for a long time for want of water.

The ſamples which accompanied this letter, were two ſmall barrs, weighing only a few ounces, one of the iron made from the ſand, the other of ſteel made from the ſame iron. Theſe barrs I have tried, and found that the barr of ſteel worked extreamly well under the hammer, was very pure and clean, and free from flaws. On the contrary the barr of iron turned out much otherwiſe, for, though it appeared to bear the force of the hammer, as well as the ſteel, yet it was not near ſo pure, but broke out in flaws and hollows, almoſt through the whole of the barr, and which a welding heat would by no means bring into proper union; this however engaged us to try a different method, which was, when the barr was reduced into a proper ſize for the purpoſe, to double it up three times, one part of the barr upon the other, and to try if it would then bear welding and become more conſiſtent, and by this means we found the end perfectly well anſwered; for it bore the force of the fire and the hammer, and became in a manner perfectly ſound. This ſevere trial proved, to a demonſtration, that the iron poſſeſt all that agreable toughneſs and ductility, for which the Spaniſh iron is ſo deſervedly famous, without partaking of that vile redſhire quality, for which the latter is very remarkable, and manifeſtly tends to prove the excellency of this ſand iron, when reduced into barr iron under proper care and circumſpection.

You will obſerve, Sir, from the letter, that this ſand is ſo pure, and ſo clean waſhed, that their firſt method of reducing the ſand to barr iron proved too tedious, for want of ſome of thoſe adventitious materials, to promote and perform the ſmelting, and which always accompanies the common ore, whether it be of the rock or bog kind; which materials, mixing with the matter, made uſe of by way of flux, and uniting with the aſhes of the fuel employed in melting down the ore, is uſually run into a thick opake glaſſy ſubſtance, forming, as it were, a covering over the metal, which, by its gravity, naturally ſinks to the bottom; this the workmen call cinder. Now the want of this matter rendering the operation too tedious, I find they had recourſe either to this cinder brought from other iron works, or to a quantity of the bogmine, which, I doubt not, would abundantly furniſh matter for cinder. If they had uſed only the firſt, and that properly choſen, it might very probably have been of ſome ſervice, without doing any material injury to the metal; but if the bog mine is uſed, though the ſervice might be apparently more, yet in all likelihood the injury would be infinitely great, and I am inclined to believe that ſomething of this kind occaſioned the difference obſerved between the two barrs above mentiond, viz. that the one might have been reduced by the help of more pure materials, and the other by the aſſiſtance of their bogmine, whoſe conſtituent parts abounding with many impurities, ſome of which, by mixing with the metal, may have occaſioned the defects above complained of, and which required ſo ſevere an operation both of the fire and hammer to ſeparate from it. I am therefore of opinion, that as the proſecution of this uſeful diſcovery deſerves the greateſt encouragement, if the Society of arts and manufactures ſhould take it under their patronage, the premium they may think proper to propoſe ſhould rather be given to the perſon who ſhall produce the pureſt metal, than to him who ſhall produce the greateſt quantity, for otherwiſe, I am afraid, we ſhall be deprived of what I ſhould eſteem the moſt valuable part of this diſcovery, I mean the obtaining a more pure, and better kind kind of iron, than any we have hitherto been poſſeſt of, and which I am certain this ſand, under proper management, is capable of producing.

I am,

Sir, with the greateſt reſpect,

Your moſt obedient

Feb. 5, 1763.

humble ſervant,

Henry Horne.